

**Advanced Remote Display Station
REFERENCE MANUAL**



Computer Displays Inc.

ADVANCED REMOTE DISPLAY STATION (ARDS)

REFERENCE MANUAL



Computer Displays Inc.

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PREFACE

The ARDS graphic display terminal has been developed by Computer Displays Inc. to provide Science and Industry with an effective Man/Computer interface. It incorporates the latest developments in display technology and includes features not available in competitive systems. The following pages highlight the capabilities of ARDS and describe its general operation.

TABLE OF CONTENTS

	<u>Page</u>
CHAPTER 1 BASIC ARDS DESCRIPTION	1
1. 0 Introduction	1
1. 1 ARDS Hardware	1
1. 2 Display	3
1. 3 Keyboard	5
1. 4 Controller	7
1. 4. 1 Symbol Mode	8
1. 4. 2 Graphic Mode	8
1. 4. 3 Format	10
CHAPTER 2 COMMUNICATION INTERFACE	16
2. 0 Introduction	16
2. 1 Full-Duplex Operation	16
2. 2 Half-Duplex Operation	17
2. 2. 1 Equipment	17
2. 2. 2 Operation	19
2. 3 Electrical Interface for Data Transmission	21
2. 3. 1 Interface Signal Descriptions	25
2. 3. 2 Input and Output Circuits	27
CHAPTER 3 OPERATIONAL FEATURES	29
3. 0 Introduction	29
3. 1 Graphic Input Option	29
3. 1. 1 The Mouse	31
3. 2 Multi-Symbol Sizes	32
3. 3 Right Margin Detect Option	33
3. 4 Multi-Scope Electronics Option	33
3. 5 High-Speed Option	34
3. 6 Answerback Option	34
3. 7 Multiple Symbol Set Option	35
CHAPTER 4 ARDS OPERATING INSTRUCTIONS	36
4. 0 Applying Power	36
4. 1 Establish Communication	36
4. 2 General Operation	36

LIST OF FIGURES

<u>Number</u>		<u>Page</u>
1	Advanced Remote Display Station (ARDS)	0
2	ARDS Display Screen	2
3	Keyboard Layout	4
4	USASCII Character Assignments	6
5	Set Point Mode	11
6	Long Vector Mode	12
7	Short Vector Mode	13
8	Flow Diagram for a Single Character Received by ARDS	15
9	Timing Diagram of 202C2 Data Set Control Signals	18
10	Input (a) and Output (b) Circuits	28
11	Mouse, Graphic Input Device	30

LIST OF TABLES

<u>Number</u>		<u>Page</u>
1	Keyboard Special Function Lights and Buttons	7
2	Control Character Action	9
3	Pin Assignments On ARDS Interface Connector	22
4	Cable for 202C2 or 202C6 Data Set	23
5	Cable for 103 Data Sets	24
6	Cable for High Speed Operation	26



Figure 1. Advanced Remote Display Station (ARDS).

CHAPTER 1

BASIC ARDS DESCRIPTION

1. 0 Introduction

Computer Displays Advanced Remote Display Station (ARDS) is an important innovation in computer terminals. It couples third generation electronics with a new display technology that allows a complete graphic station to be built into a self-contained, desk-top console. An almost unlimited amount of complex graphics as well as alphanumeric symbols can be drawn on ARDS with remarkably precise detail yet absolutely free of flicker or drift.

ARDS is designed to communicate with any computer, either directly connected, or over a standard telephone line. ARDS interface is extremely simple. To the computer it looks like a teletypewriter, except that it can communicate data at 1200 bits per second (or faster). ARDS transmits and receives data in character asynchronous, bit-serial form. The code used is ASCII.

Although ARDS is an exceedingly versatile terminal in its basic form, many users require specialized equipment for their terminal application. A variety of hardware options are available to satisfy these needs.

1. 1 ARDS Hardware

The basic ARDS unit logically and physically consists of three parts: controller, display unit, and keyboard. The controller forms the base of the entire unit. The keyboard normally attaches to the controller housing as shown in Figure 1, but it can be separated and connected by cable. Detaching the keyboard allows access to the logic cards of the controller. The display unit mounts above the controller. It can also be easily removed for access to the electronics below.

The display unit contains a direct-view storage CRT. The surface of the display unit acts as the console's memory, and serves the double purpose of image storage and viewing screen. Once data is written on the surface of the display unit, it remains visible for more than 15 minutes without noticeable degradation. To clear the viewing surface for fresh data, the screen of

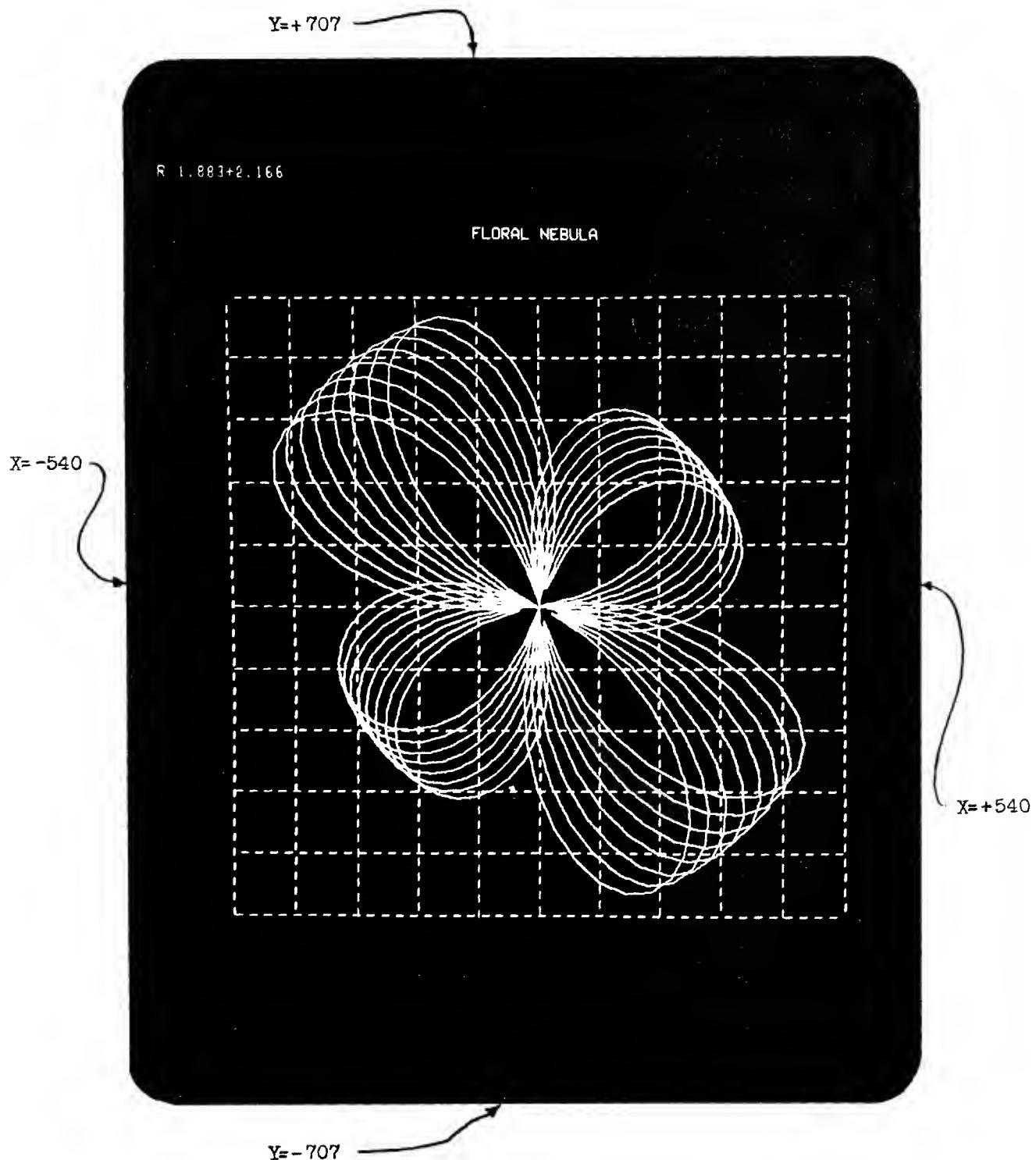


Figure 2. ARDS Display Screen .

the display unit erases in one-half second. The display can also present a "non-storing" cursor, which can be moved about on the screen without leaving a trace behind it. This is useful for locating beam position and for graphic input.

In normal operation the keyboard provides alphanumeric input to the computer and to the display unit. It contains keys for generating all 128 possible codes of ASCII. Patterned after a normal typewriter, the keyboard contains a pair of shift keys, and shift lock. Repeat of a key is also available as an option.

The controller of ARDS contains the digital logic of the system. In it is the electronics associated with the computer interface, the code conversion and analog signal generation. It contains a symbol generator and a vector generator, which permit extraction of the fullest information transmission capacity of a narrow band communication link to the computer.

The controller also contains the logic for formatting and transmitting the data from the keyboard into the computer. The input section and the output section of the controller are functionally separate, although data transmitted from the keyboard can be fed back locally to the output section.

1.2 Display

The viewing area of the display unit is 8 1/4" x 6 3/8". The long axis can be oriented horizontally, although normally it is vertical in the manner of a page of text. The spot size of the display unit is nominally 8 mils. When two spots are plotted together on 12-mil centers, they will merge together to form one elongated dot. Spots plotted on 20-mil centers will appear as discrete dots. With the excellent resolution of display unit, it is possible to plot over 4,000 easily legible symbols.

For graphics, the display screen is defined to contain 1081 x 1415 addressable points (these are not necessarily resolvable points). With a vertical orientation of the long axis of the screen, the vertical edges have x addresses of +540 and -540, and the horizontal edges have y addresses of +707 and -707 (see Figure 2). The point 0, 0 is in the center of the screen. When necessary, however, both the number of addressable points and the location of the 0, 0 can be adjusted. Because of the method used to keep track



Figure 3. Keyboard Layout.

of beam position, pictures can run more than 8 inches off the screen in any direction before causing any distortion. Thus, no special precautions must be taken if the user's total picture is somewhat larger than the viewing window of the display. The display unit can draw lines at the rate of 1/2 inch per millisecond. Characters can be printed in 1 to 2 milliseconds. However, in applications where the display is remote from the computer, the transmission rate of the telephone line limits the writing rate. On a Bell System 202 Data Set this is 120 characters per second, which is roughly 10 times faster than teletypewriters operate. The display unit erases in 500 milliseconds.

ARDS is unique in that any image displayed, no matter how complex, will be absolutely free of drift, wobble or flicker. The amount of data displayed in no way affects the visual quality of the display. This performance is achieved through use of the direct-view storage CRT.

1.3 Keyboard

The ARDS Keyboard contains 58 keys and is capable of transmitting all 128 ASCII codes.

There is no character storage in ARDS so that each key, as it is struck, transmits the associated character to the computer. The characters transmitted may also be coupled back within the controller to the output printing section of ARDS, so that striking a key will cause the symbol to appear on the screen. This local "echo" may be suppressed under program control, as discussed in Section 1.4.1.

Figure 3 shows the keyboard layout. Most keys are normal printing characters or are standard carriage controls. Shift causes upper case characters to be transmitted. The Erase key sends the FF (Form Feed) character. If the output (printing) section of ARDS receives FF, it erases the screen and moves the beam to the upper left hand corner of the screen ($x = -525$, $y = 690$). The Control key causes bits 6 and 7 to be suppressed (forced to zero) on any key struck in conjunction with Control. The mapping for printing characters into control characters is shown in Figure 4.

In addition, the keyboard contains the power switch plus special function lights and switches as listed in Table 1.

Bit Positions				b7	b6	b5	0	0	0	0	1	0	1	0	1	0	1	1	1
b4	b3	b2	b1				0	0	0	1	0	1	1	0	0	1	0	1	1
0	0	0	0	NUL	DLE	SP		0		@	P	'	p						
0	0	0	1	SOH	DC1	!		1		A	Q	a	q						
0	0	1	0	STX	DC2	"		2		B	R	b	r						
0	0	1	1	ETX	DC3	#		3		C	S	c	s						
0	1	0	0	EOT	DC4	\$		4		D	T	d	t						
0	1	0	1	ENQ	NAK	%		5		E	U	e	u						
0	1	1	0	ACK	SYN	&		6		F	V	f	v						
0	1	1	1	BEL	ETB	/		7		G	W	g	w						
1	0	0	0	BS	CAN	(		8		H	X	h	x						
1	0	0	1	HT	EM	)		9		I	Y	i	y						
1	0	1	0	LF	SUB	*		:		J	Z	j	z						
1	0	1	1	VT	ESC	+		;		K	[	k	{						
1	1	0	0	FF	FS	,		<		L	\	l	|						
1	1	0	1	CR	GS	-		=		M	]	m	}						
1	1	1	0	SO	RS	.		>		N	^	n	-						
1	1	1	1	SI	US	/		?		O	_	o	—						DEL



Control
Characters



Second Category Representing
Argument (Includes the Control
Character DEL)



Communication
Control Characters



Key Characters



Central Character DEL
Included in the Argument Set

Figure 4. USASCII Character Assignments.

TABLE 1.
KEYBOARD SPECIAL FUNCTION LIGHTS AND BUTTONS

<u>Device</u>	<u>Function</u>
BREAK button	Sends "Break" signal.
HALT/PROCEED light	HALT indicates that the computer has the transmission line and the Keyboard is disabled (half duplex only). PROCEED indicates that the user has the line and can transmit from his Keyboard.
RESET button	Resets ARDS to symbol mode, enables the output section, and resets the beam to center screen (0, 0).
PARITY ERROR lighted button	Indicates that received data contained a parity error. Pushing the button resets the light.

The HALT/PROCEED light and BREAK button are provided to give proper control in half-duplex operation on ARDS. The HALT/PROCEED light indicates to the operator whether he or the computer has control of the line. The BREAK button provides a signal which cannot be disabled and can be used to interrupt the computer. Thus, the BREAK allows the user to override the computer. The operation of these are explained in more detail in Chapter 2 (Half and Full Duplex Operation).

1.4 Controller

The controller can be considered to have two sections: input and output. The input section, along with the keyboard and Graphic Input Option (if provided), creates, formats and transmits data to the computer. The output section with the display receives, decodes and prints data from the computer. It contains the symbol generator, vector generator, and serial-to-parallel buffers for creating pictures on the display.

The format for the commands that the controller interprets is described in detail in Section 1.5. Suffice it to say here that the controller can be put into either of two modes: symbol or graphic. In symbol mode, ARDS acts like a normal teletypewriter except for its higher operating speed. In graphic mode, ARDS interprets characters, not as symbols to be plotted, but as binary data for drawing lines or plotting points.

1.4.1 Symbol Mode

The symbol generator set contains the 96 printable symbols (counting Space and Delete) of the American Standard Code for Information Interchange (ASCII). (Figure 4 illustrates the ASCII symbols.)

Although symbol size can be adjusted to the user's requirements, the standard size is 12 characters per inch. This permits 80 symbols per line and 50 lines to be displayed with the normal tube orientation. The symbol set is formed on a 7 x 9 dot matrix which can be dropped two dot locations for symbols that hang below the line. Symbols are plotted below and to the right of the beam position at the start of a character.

Options for multiple symbol sizes, variations from the standard symbol set, and a second set of 96 additional symbols are discussed in Chapter 3 (Optional Features).

In symbol mode ARDS will act as any teletypewriter, plotting any printing character received and moving the beam to the right one symbol position.

In addition to the symbols, ARDS also interprets certain of the control characters and takes the action described in Table 2. Note that a number of these are optional features.

In particular it should be noted that the Tab function is not implemented in the standard ARDS hardware. The Tab key will transmit the Tab code (011) but the display will ignore it. Because of ARDS random point plotting and vector generation capability, Tab half-line-feed (subscript and superscript) and similar carriage controls can easily be implemented in software. A hardware Tab is available as a special option.

1.4.2 Graphic Mode

In graphic mode ARDS can position the beam in absolute coordinates. The command to position the beam, called a Set Point command, specifies the coordinate values as sign-magnitude numbers. Magnitudes for x and x are 10 bits each.

TABLE 2
CONTROL CHARACTER ACTION

<u>Character</u>	<u>Code</u>	<u>Action</u>
Line Feed	012	Repositions the beam down one text line.
Carriage Return	015	Repositions beam to left edge of screen (X = -525).
Back Space	010	Moves beam to left one symbol position.
Form Feed	014	Erases screen and position beam to left margin and top of page (x = -525, y = 690).
Bell	007	Rings bell once.
DC2	022	Disables the connection between the keyboard and the output section of ARDS. Keyboard will not print, but will transmit to computer. Output section accepts data from computer.
DC4	024	Enables the connection between the keyboard and the output section of ARDS.
ETX	003	Disables the output section of ARDS from the computer. Keyboard will still print and transmit.
STX	002	Enables the output section of ARDS from the computer.
ENQ*	005	If the Answerback option is provided ARDS will transmit an eight-character "ID Message."
Tab*	011	If the hardware Tab option is provided, Tab causes the beam to move right to the next Tab stop. Tab stops are fixed at increments of 10 spaces across the scope.

* optional

The vector generator also operates on sign-magnitude numbers and draws vectors relative (Δx , Δy) to the last beam position. Magnitude values for Δx and Δy are 10 bits each and thus lines can have x and y components up to 1023 increments, which is full screen width. An increment is approximately .006 inches. The vector generator is able to draw any line in 8.33 milliseconds, the time required to accept one character at 1200 bits per second. Vectors can be blank, intensified, or dotted under program control.

1.4.3 Format

The data format of ARDS is compatible with ASCII, the symbol set contains the 96 printable ASCII symbols. To accommodate graphic input and output, ARDS operates under mode control. ARDS is set into symbol mode by any of the ASCII control characters (bit 7 = bit 6 = ZERO) with the exception of three that are reserved for graphic mode.

Since ASCII does not have any provision for sending "graphic" information, a scheme for extending the code for ARDS has been adopted. This extension, which does not violate the basic precepts of ASCII, provides for a large number of "graphic commands," each of which can interpret "binary" characters as arguments. Most of these commands are not assigned and are available for future extensions. The standard ARDS responds to three graphic commands as indicated below:

1. Set Point will locate the beam to any absolute location on the screen.
2. Long Vector will draw a relative vector any length up to 1023 increments in any direction, blanked, or visible; solid or dotted.
3. Short Vector will draw a relative vector in any direction any length up to 31 increments, always visible and solid.

ASCII control codes GS, RS or US (octal 035, 036, 037) will cause ARDS to enter graphic mode and in particular the Set Point, Long Vector or Short Vector submodes respectively. See Figures 5, 6, and 7. Once in graphic mode ARDS looks for "binary" characters to be arguments of the submode. Binary characters are those with bit 7 = ONE. Thus they contain just 6 bits of information. By this assignment, binary data never looks like communications control characters which may cause undesired actions along the communications line (such as EOT turning off the line).

Enter Set Point Mode with ASCII Control Code GS

Stop	Parity	b_7	b_6	b_5	b_4	b_3	b_2	b_1	Start
1	P	0	0	1	1	1	0	1	0

In Set Point Mode data is taken in blocks of four (4) binary characters ($b_7 = 1$) in the following format:

Stop	Parity	b_7	b_6	b_5	b_4	b_3	b_2	b_1	Start
1	P	1	2^4X	2^3X	2^2X	2^1X	2^0X	Sign X	0

Character 1

1	P	1		2^9X	2^8X	2^7X	2^6X	2^5X	0
---	---	---	--	--------	--------	--------	--------	--------	---

Character 2

1	P	1	2^4Y	2^3Y	2^2Y	2^1Y	2^0Y	Sign Y	0
---	---	---	--------	--------	--------	--------	--------	--------	---

Character 2

1	P	1		2^9Y	2^8Y	2^7Y	2^6Y	2^5Y	0
---	---	---	--	--------	--------	--------	--------	--------	---

Character 4

Figure 5.* Set Point Mode.

- * In the Set Point (GS) submode, ARDS interprets the next four binary characters as x and y data (sign plus 10 bits magnitude each) plus a bit to control whether to intensify the point or not. Succeeding binary characters are interpreted as data for more Set Points.

Enter Extended Vector Mode with ASCII Control Code Rs

Stop	Parity	b_7	b_6	b_5	b_4	b_3	b_2	b_1	Start
1	P	0	0	1	1	1	1	0	0

In Extended Vector Mode data is taken in blocks of four (4) binary characters ($b_7 = 1$) in the following format:

Stop	Parity	b_7	b_6	b_5	b_4	b_3	b_2	b_1	Start
1	P	1	$2^4 \Delta X$	$2^3 \Delta X$	$2^2 \Delta X$	$2^1 \Delta X$	$2^0 \Delta X$	Sign X	0

Character 1

1	P	1	INT	$2^9 \Delta X$	$2^8 \Delta X$	$2^7 \Delta X$	$2^6 \Delta X$	$2^5 \Delta X$	0
---	---	---	-----	----------------	----------------	----------------	----------------	----------------	---

INT = Intensified Control

Character 2

1	P	1	$2^4 \Delta Y$	$2^3 \Delta Y$	$2^2 \Delta Y$	$2^1 \Delta Y$	$2^0 \Delta Y$	Sign Y	0
---	---	---	----------------	----------------	----------------	----------------	----------------	--------	---

Character 2

1	P	1	D	$2^9 \Delta Y$	$2^8 \Delta Y$	$2^7 \Delta Y$	$2^6 \Delta Y$	$2^5 \Delta Y$	0
---	---	---	---	----------------	----------------	----------------	----------------	----------------	---

Character 4

D = Dotted Line Control

Figure 6.* Long Vector Mode.

- * In the Long Vector (RS) submode, ARDS interprets the next four binary characters as Δx and Δy data (sign plus 10 bits magnitude each) plus a bit to control whether to intensify the line or not, and a bit to control whether intensified lines should be solid or dotted. Succeeding binary characters are interpreted as data for more Long Vectors.

Enter Short Vector Mode with ASCII Control Code US

Stop	Parity	b_7	b_6	b_5	b_4	b_3	b_2	b_1	Start
1	P	0	0	1	1	1	1	1	0

In Short Vector Mode data is taken in blocks of two (2) binary characters ($b_7 = 1$) in the following format:

Stop	Parity	b_7	b_6	b_5	b_4	b_3	b_2	b_1	Start
1	P	1	$2^4 \Delta X$	$2^3 \Delta X$	$2^2 \Delta X$	$2^1 \Delta X$	$2^0 \Delta X$	Sign X	0

Character 1

1	P	1	$2^4 \Delta Y$	$2^3 \Delta Y$	$2^2 \Delta Y$	$2^1 \Delta Y$	$2^0 \Delta Y$	Sign Y	0
---	---	---	----------------	----------------	----------------	----------------	----------------	--------	---

Character 2

Figure 7.* Short Vector Mode.

- * In the Short Vector (US) submode, ARDS interprets the next two binary characters as Δx and Δy data (sign plus 5 bits magnitude each). Short Vectors are always intensified. Succeeding binary characters are interpreted as data for more Short Vectors.

ARDS will stay in a submode until it receives a character that takes it to another submode or back to symbol mode.

In addition to the three submodes described, 32 unassigned submodes are provided. These are entered from Set Point, Long Vector, or Short Vector submodes by receiving one of the 32 characters which have bit 7 = ZERO and bit 6 = ONE (called Key character). See Figure 4. These submodes are reserved for adding optional features to ARDS, e.g., multiple displays, multiple symbol sizes, etc. or for control of other equipment (tape recorder, camera, etc.). Chapter 3 describes the uses of some of these modes for control of optional equipment.

ARDS is returned to symbol mode by any control character other than GS, RS, or US. In addition to returning to symbol mode, ARDS will act properly on the control character, i.e., FF will pull ARDS out of graphic mode, erase the screen and reposition the beam.

Figure 8 is a flow diagram of ARDS format control.

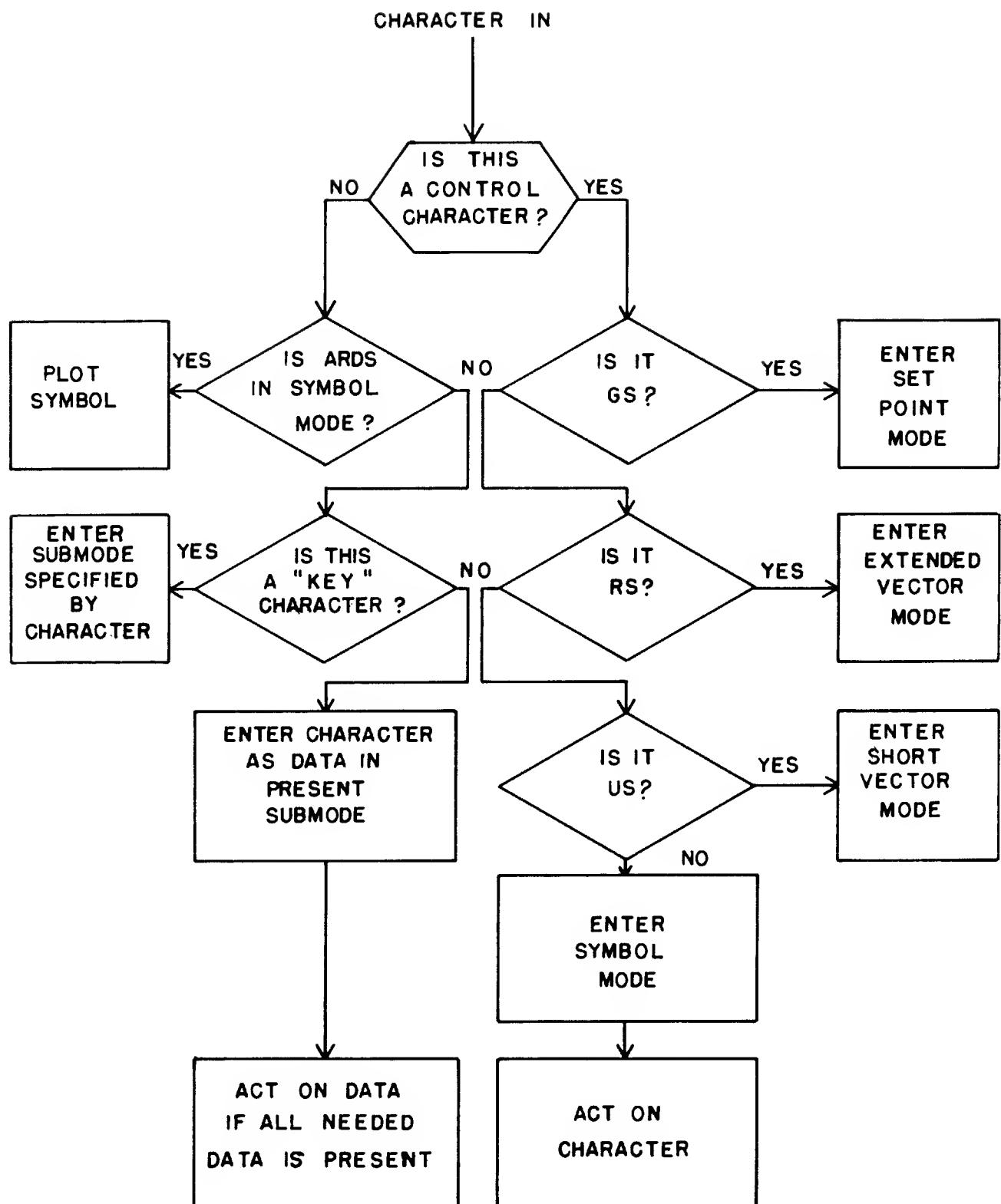


Figure 8. Flow Diagram for
a Single Character Received by ARDS.

CHAPTER 2

COMMUNICATION INTERFACE

2.0 Introduction

ARDS is designed to operate with a computer either over telephone lines via standard Bell System data sets or locally connected by direct cable.

For operation with data sets, ARDS is constrained to a maximum speed of 1200 bits per second; it can run at any lower speed. If direct connection is provided, and the appropriate adapter is provided on the computer, ARDS can be run at higher speeds with incorporation of the High Speed Option.

ARDS communicates in ASCII 8 level code (7 data bits plus parity). It operates in a bit-serial, character asynchronous manner which is sometimes referred to as STOP/START communications. That is, each 8 bit character is bracketed with a START bit and a STOP bit. The START bit allows the receiving device to initiate its timing in proper synchronism with the incoming data. The STOP bit ensures that the communication line is returned to the marking condition ready for a new START. To be compatible with certain teletypewriters ARDS actually transmits one START and two STOP bits with each character sent. When receiving data however, ARDS looks for just one STOP bit. Thus, ARDS will operate properly with 10 or 11 bit formats. ARDS operation is compatible with EIA standard RS-232B. The pin connections and connector type for this interface is shown in Table 3.

2.1 Full-Duplex Operation

ARDS operation is the simplest in the full duplex mode. This is the case when communication channels are provided in both directions (sending and receiving) simultaneously. This can be achieved with a direct connection to a computer, on a private line telephone hookup, or on a dialed-up low speed data set, e.g., Bell 103 Series data set operating at 110 bits per second. In direct connection or on a private wire phone system, this means a send wire pair and a receive wire pair are provided. On a dialed-up low speed data set, the send and receive channels are provided by frequency multiplexing the single switched pair of wires.

In full-duplex operation, any characters generated at the keyboard are transmitted to the computer, regardless of activity on the receive data line. These characters may be fed back to the output section of ARDS directly, or they may be echoed through the computer. The control characters DC2 and DC4 determine whether ARDS locally echoes or not.

In full duplex the PROCEED/WAIT light has no significance, since the keyboard is always enabled. The BREAK button causes a 250 millisecond pulse of "Space" to appear on the transmit data line. Note that although STX and ETX have no real function in a full-duplex connection, ARDS still interprets and acts on them.

2.2 Half-Duplex Operation

To operate over a telephone line at 1200 bits per second a Bell System 202 data set is required. A 202 data set needs nearly the full bandwidth capability of the normal telephone line to transmit 1200 bits per second data in one direction. For this reason, a 202 data set can only operate in "half-duplex" over a single pair of wires. (Half-duplex means that data can flow in both directions but not simultaneously. For half-duplex communication some form of protocol must be established to "turn the line around".) Since the telephone switching system is basically a 2-wire switch, half-duplex operation is necessary where the public dial network is utilized.

2.2.1 Equipment

Experience on computer time-sharing systems has shown that simple half-duplex protocol systems, which turn the line around only when the transmitting station is prepared to relinquish it, are not satisfactory for an interactive terminal. It is essential that both the computer and the user be able to signal that it wants the line when it is in the receiving mode.

The Bell System 202C2 and 202C6 data sets offer a "Supervisory Channel" in addition to the normal 1200 bits per second forward data channel. This Supervisory Channel is very slow (5 bits per second), and always functions in the reverse direction from the data. That is, if the computer is transmitting, the terminal controls the Supervisory Channel and vice-versa. Although limited, the Supervisory Channel does provide the necessary reverse signal path that interactive half-duplex operation requires.

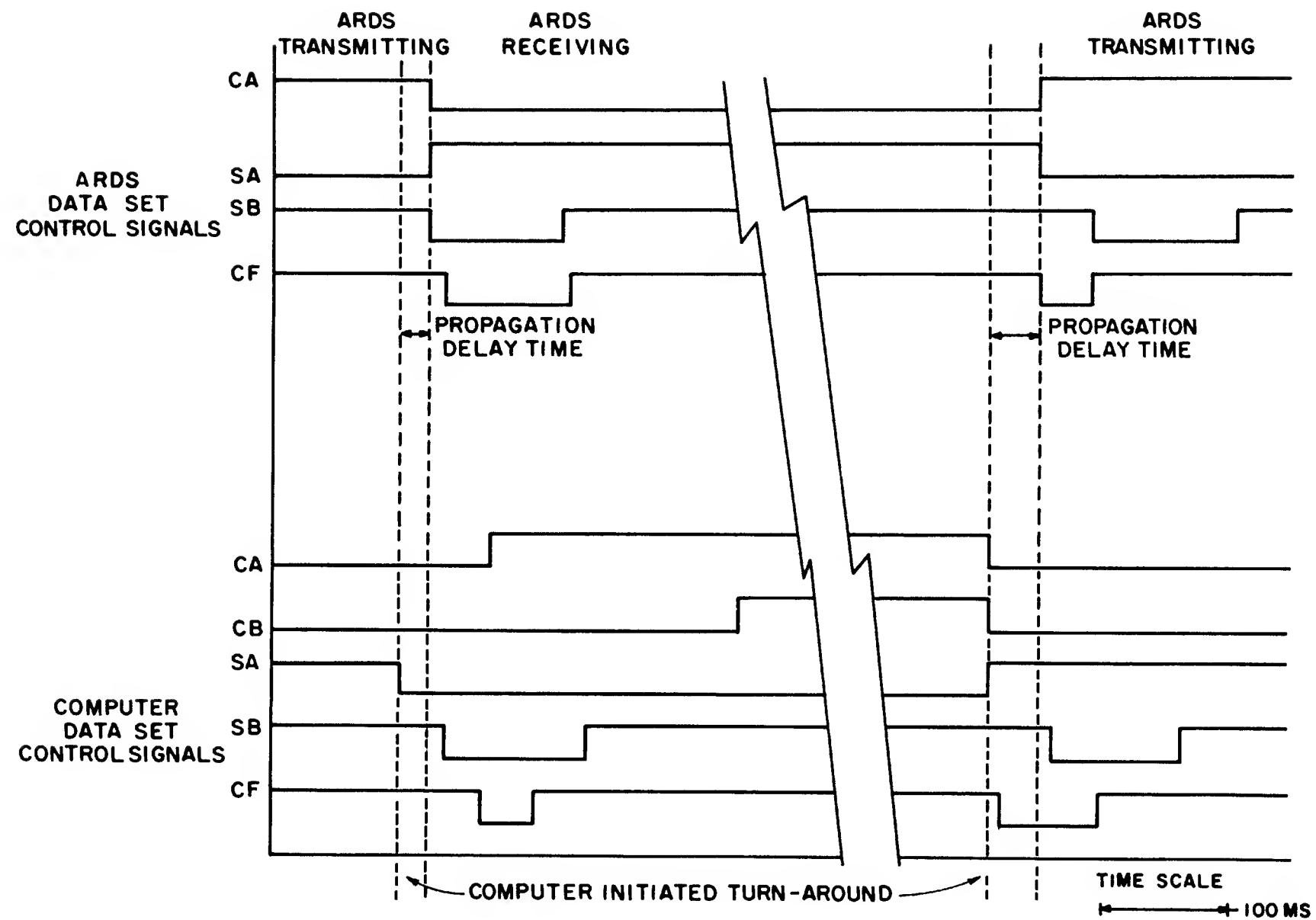


Figure 9. Timing Diagram of 202C2 Data Set Control Signals.

2.2.2 Operation

Normally the channel is set up to transmit from the ARDS to the computer. Only when the computer has data ready for transmission to the ARDS will the computer initiate a channel turn-around. As soon as the computer has sent all the data it wants to send at the moment, it will relinquish the channel. ARDS will automatically switch back to the normal transmitting (PROCEED) state.

At all times the ARDS user has the capability to interrupt the computer via the BREAK signal. Often this interrupt is used to request the computer to send a message to the ARDS; and the computer, as a result, will turn the channel around. However, an interrupt by the ARDS user will never directly turn the channel around. Only the program in the computer can initiate channel turn around by generating a message.

Terminology used in this description of the operation of an ARDS over a 202 half-duplex line is taken from the Bell System Data Communication Technical Reference on Data Set 202C Interface Specification of May 1964. Figure 9 shows the timing sequence of half-duplex operation.

In the dormant state, where neither the computer nor the terminal have data to send, ARDS will be considered to be the transmitting station. It will keep its Request to Send (CA) "ON". By the same token the computer will be in Receive mode, with its CA "OFF" and its Supervisory Transmitted Data (SA) "ON".

From this state, if the user strikes a key on his keyboard, ARDS merely sends the character out over its Transmitted Data line (BA). The message termination can be handled by whatever mechanism is chosen by the computer.

When the computer is to transmit data to the terminal, the line must be "turned around", i.e., switched to the state where the computer is transmitting and the terminal receiving. To accomplish this on the half-duplex 202C2 data set, the computer first turns "OFF" its Supervisory Transmit (SA). When ARDS sees its Supervisory Received Data (SB) drop, it immediately shuts off its CA and goes to the WAIT state.

The computer I/O meanwhile looks for its Data Carrier Detection Line (CF) to drop indicating that the line is now free. It immediately brings up its Request to Send (CA). The computer then waits for Clear to Send (CB) to be returned (after a fixed delay of approximately 200 milliseconds). When this signal comes "ON", data can be sent.

The terminal, which has gone to the WAIT state (receiving), will stay in this state so long as it is receiving carrier (CF) from the computer. Since there is a time delay from when Supervisory Received Data (SB) first drops until when the terminal first sees Data Carrier Detect (CF), the terminal is forced to stay in the WAIT state, insensitive to the state of CF, for 500 milliseconds. If CF has not come up after 500 milliseconds, ARDS drops back into the PROCEED state and brings up Request to Send (CA).

Once the computer has the line, it sends its message. Upon completion of the message, the computer drops its Request to Send (CA), turns on its Supervisory Transmit (SA), and goes to the receive mode. When the terminal sees Data Carrier Detect drop (CF), it immediately switches back to the PROCEED state, brings up Request to Send (CA) and drops Supervisory Transmit (SA). Since the Supervisory Channel is very slow (5 bits per second), the terminal is forced to stay in the PROCEED state for a period of 1 second, insensitive to the state of Supervisory Received Data (SB).

Unfortunately, the 202 data set is subject to noise transients when carrier is turned ON or turned OFF. To the receiving machine these noise spikes can look like data. To prevent these errors from printing, ARDS is built to respond to Start of Text (STX) and End of Text (ETX) characters. Receipt of ETX causes ARDS to ignore all subsequent characters from the data set (BB) except STX. When STX is received, ARDS becomes sensitive to characters again. The computer then can bracket its messages with STX and ETX characters and block ARDS during the line turn-around procedure. Note that ARDS is only blinded to characters received from the data set (i.e. from the computer) and not to characters that its keyboard transmits. Since the computer controls line turn-around, it knows when to ignore its Received Data (BB). This eliminates the need for the user to bracket typed messages with STX and ETX.

Another consideration in the half-duplex protocol is the procedure for the user issuing the BREAK signal. This signal is used to interrupt the computer immediately and must be available to the user in either the PROCEED or the WAIT state.

The BREAK button on ARDS causes two actions to be taken:

(1) A 250 millisecond pulse of "space" is put on the Transmitted Data line (BA), and (2) the Supervisory Transmitted Data (SA) is turned "OFF" for 250 milliseconds. If ARDS is in the PROCEED state, the 250 millisecond pulse on BA carries the "BREAK" information since SA is already off. In the WAIT state, dropping SA carries the information since BA is ignored if Request to Send (CA) is OFF. ARDS does not attempt to turn the line upon transmitting BREAK. The computer will always control this function.

The computer system interrupt should be triggered by either the receipt of 250 milliseconds of "space" when receiving data, or on detection of SB dropping for 250 milliseconds when transmitting. Note that SB will not be ON immediately after the computer turns the line around to transmit. The computer must therefore blind its BREAK detection circuit for some fixed delay, preferably one second, after it requests to send.

2.3 Electrical Interface for Data Transmission

The ARDS Electrical Interface matches the Electronic Industries Associations Standard RS-232B. This permits ARDS to be connected directly into most available modems. In addition to signals defined in the above standard, ARDS provides extra control signals to allow the terminal to be operated half- or full-duplex at 110 baud, 1200 baud, or higher bit rates. Table 3 illustrates the pin assignments for this connector.

As can be noted in Table 3, there are two "Received Data" inputs to ARDS (Pins 3 and 13). By using the Pin 3 input, ARDS can be used with half-duplex data sets such as the 202C; in addition, ARDS responds to the special "Reverse Channel" signals 'Supervisory Received' and 'Supervisory Transmitted Data' used with data sets such as the 202C2 and 202C6. Table 4 shows the cable connections for these data sets. By using the Pin 13 input, ARDS can be used in full-duplex mode in which data transmission both to and from ARDS can occur simultaneously. It is important to note that normally ARDS

TABLE 3
PIN ASSIGNMENTS ON ARDS INTERFACE CONNECTOR*

<u>Pin</u>	<u>Circuit</u>	<u>Description</u>
1	AA	Protective Ground
2	BA	Transmitted Data
3	BB1	Received Data, Half-Duplex
4	CA	Request to Send
5	CB	Clear to Send
6	CC	Data Set Ready
7	AB	Signal Ground
8	CF	Data Carrier Detect
9	Not Used	
10	Not Used	
11	SA	Supervisory Transmitted Data
12	SB	Supervisory Received Data
13	BB2	Received Data, Full-Duplex
14	CJ	Data Demand
15	Not Used	
16	Not Used	
17	Not Used	
18	Not Used	
19	Not Used	
20	CD	Data Terminal Ready
21	Not Used	
22	Not Used	
23	Not Used	
24	Not Used	
25	Not Used	

*ARDS Connector Type: Cannon DB-19604-433 or Equivalent.

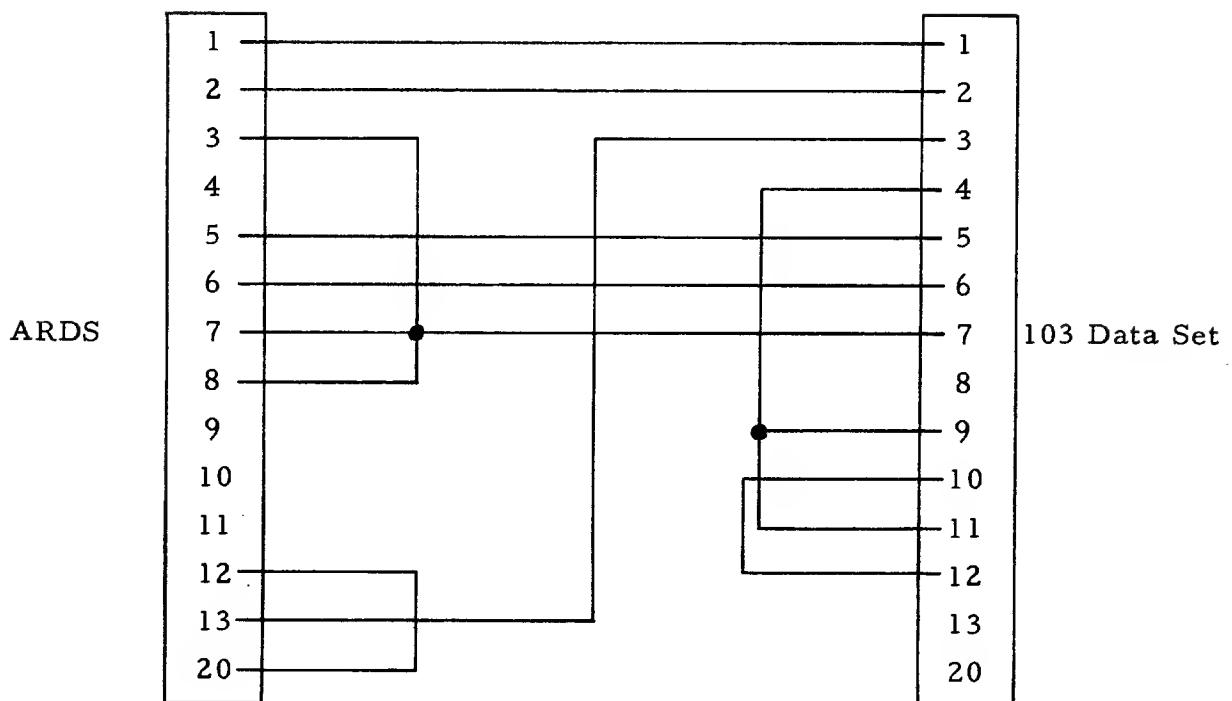
Mates with: Cannon DB-19604-432

TABLE 4
CABLE FOR 202C2 OR 202C6 DATA SET

ARDS		202 Data Set
1	AA	1
2	BA	2
3	BB	3
4	CA	4
5	CB	5
6	CC	6
7	AB	7
8	CF	8
11	SA	11
12	SB	12
20	CD	20

Both connectors are Cannon DB-19604-432

TABLE 5
CABLE FOR 103 DATA SETS



Both connectors are Cannon DB-19604-432

"closes the loop" internally so that all information that is typed on the keyboard appears automatically on the viewing screen. For systems which "echo" characters, the local print feature of ARDS must be wired out or turned off by transmitting the DC2 character (022). The full-duplex mode is often used with 103 data sets; Table 5 shows cable connections for this data set.

For systems where the data transmission link is not bandwidth limited, the ARDS clock speed can be increased to as great as 100 kilobits as a High Speed Option. When this option is included, Pin 14 provides a "data demand" signal to indicate when ARDS is ready to accept data. Table 6 shows the cable connections for this type of connection. It is recommended that cable lengths in all cases not exceed 20 feet in length.

2.3.1 Interface Signal Descriptions

Circuit AA Protective Ground - This conductor is electrically connected to machine frame and to the third lead of the power cord.

Circuit AB Signal Ground - Common reference point for all interchange circuits.

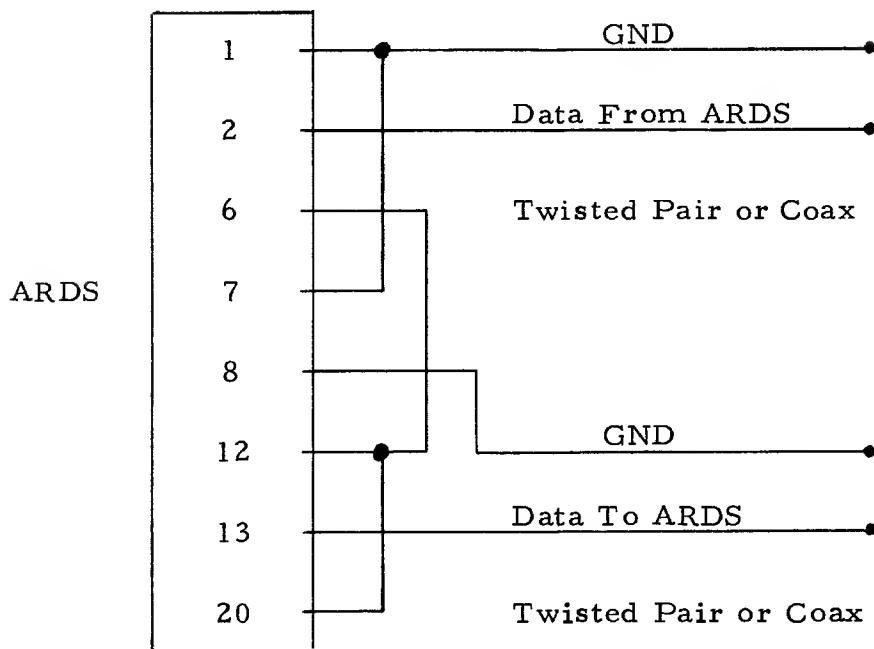
Circuit BA Transmitted Data - To data set. Transmits asynchronous, non-return-to-zero (NRZ) coding. Remains in marking condition when not transmitting. Transmission is possible only when Request to Send (CA) and Data Set Ready (CC) are ON.

Circuit BB1 Received Data, Half-Duplex Operation - From data set. Accepts asynchronous, NRZ coding. Data is accepted only when Request to Send (CA) is OFF and Data Set Ready (CC) is ON.

Circuit BB2 Received Data, Full-Duplex Operation - From data set. Acts the same as BB1 except data is not gated by any control signals and reception is always possible.

Circuit CA Request to Send - To data set. ON condition indicates ARDS wants to transmit and, conversely, the OFF condition indicates ARDS is in the receive state. In full-duplex operation, jumpers on the interface plug force CA to be ON continuously.

TABLE 6
CABLE FOR HIGH SPEED OPERATION



Connector: Cannon DB-19604-432

Customer Connector: Optional

Circuit CB Clear to Send - From data set. This signal is provided by the data set to indicate when the data set is ready to transmit. ARDS uses this signal to enable certain automatic transmissions such as "answer-back".

Circuit CC Data Set Ready - From data set. Indicates data set is operating. ARDS uses this signal to enable both BA and BB1. When CC is OFF, the keyboard lamp "WAIT" will stay on continuously.

Circuit CF Data Carrier Detect - From data set. Indicates the data set is either generating or receiving a carrier tone. Loss of a carrier will cause ARDS to turn on Request to Send.

Circuit CD Data Terminal Ready - To data set. Indicates ARDS is ON and ready to operate. When power is first applied to the machine, it may be necessary to push "reset" to turn CD ON. ARDS is set to detect the code sequence DLE EOT (020 004) and to turn CD OFF. This allows the computer to "hang up" the data set.

Circuit SA Supervisory Transmitted Data - To data set. This signal in conjunction with SB is used with 202C2 or 202C6 data sets to control a "Reverse Channel" available on these sets (see Section 2.2.2). When ARDS is receiving, pushing the "Break" button on the keyboard causes SA to turn OFF for 250 milliseconds; otherwise SA is ON whenever ARDS receives and OFF when ARDS transmits.

Circuit SB Supervisory Received Data - From data set. As stated above, the SB signal can be used by the computer to alert the ARDS while ARDS is transmitting. Normally, SB is ON when the ARDS transmits. If SB is turned OFF, ARDS goes from the transmitting mode to the receive mode, i.e., Request to Send is turned OFF.

Circuit CJ Data Demand (optional) - To data set. If this option is installed in ARDS, an ON condition indicates ARDS is ready for data and an OFF condition indicates no more data should be sent. This signal works on a character by character basis and only complete code characters should be sent. CJ goes OFF as soon as the first bit of a character is received.

2.3.2 Input and Output Circuits

The ARDS expects ON voltages to be +3 volts or more and OFF voltages to be more negative than -3 volts. The switching point is +.5 to +1.5 volts so that most integrated circuits will drive the input lines. Output levels from ARDS are +3 to +8 volts for an "ON" condition, and -3 to -8 volts for an "OFF" condition. Minimum load resistance to ground should be 3 kilohms or greater.

Received Data signals are expected to be +3 volts or more for zero or "space" and more negative than -3 volts for one or "mark". Transmitted levels conform to these specifications, also.

Actual circuits are shown in Figure 10.

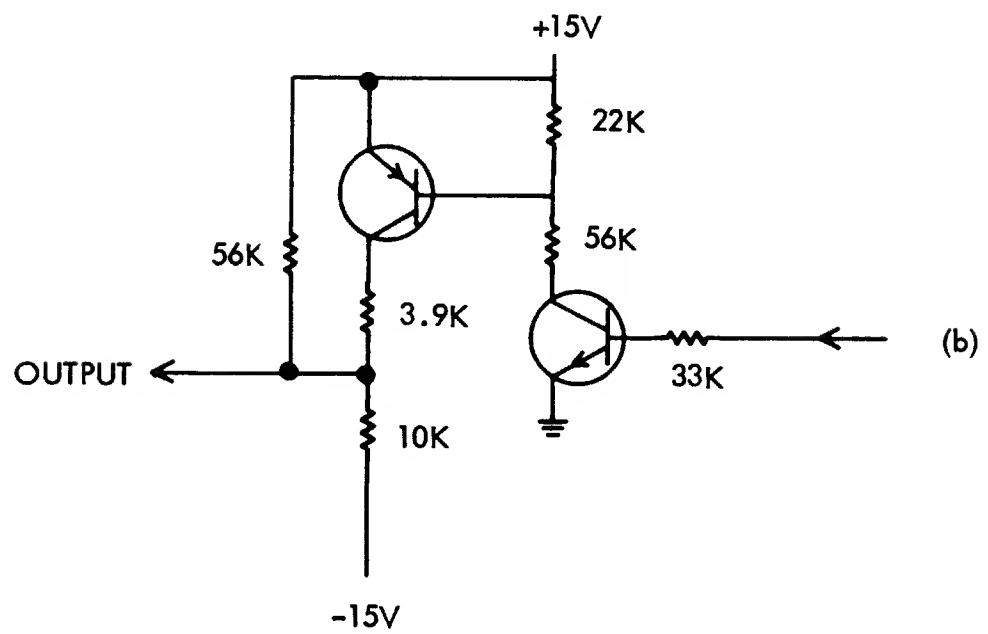
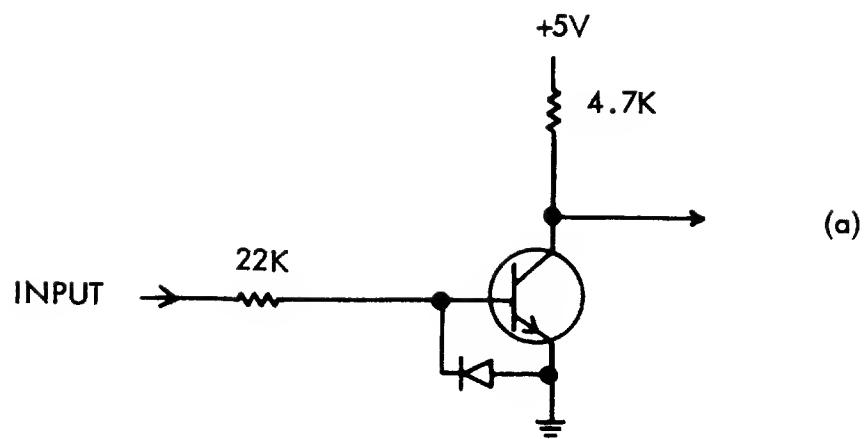


Figure 10. Input (a.) and Output (b.) Circuits.

CHAPTER 3

OPTIONAL FEATURES

3.0 Introduction

One of ARDS most useful attributes is its flexibility for adding various optional equipments to better perform for a particular application. This Chapter describes some "Standard" options. These have been designed and tested; other changes to suit a user's special needs will be considered upon specific request.

3.1 Graphic Input Option

This optional feature allows the user to conveniently converse with the computer in a graphic dialogue. Pictures can be drawn on the screen by the user and the data transmitted to the computer as it is being drawn. Also, screen locations can be identified to the computer quickly and easily. This option requires installation of the Graphic Input Electronics Option into the controller, plus a graphic input device, external to ARDS. Two graphic input devices are available. One is a Mouse, hand-held hemisphere (Figure 11) that indicates relative position as it is moved over a surface. The second device is a simple Joystick.

Moving the graphic input device causes a non-storing cursor to move on the screen in an analogous manner. Three buttons are provided which allow six character encoded messages to be sent to the computer. If the Set Point button is depressed, the message sent is the Set Point character (GS) followed by four binary characters to represent the absolute coordinate position of the cursor on the screen. The format for these binary characters is identical to the format in the Set Point command which the ARDS controller output section interprets. A final FS character ends the message to return ARDS to symbol mode.

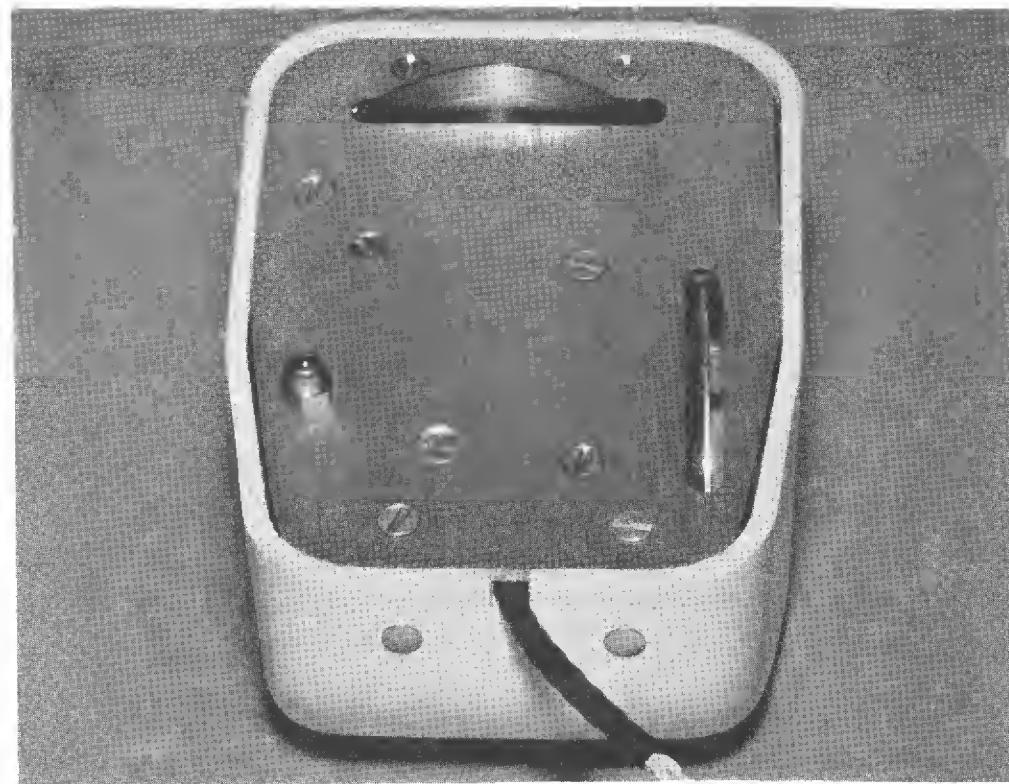
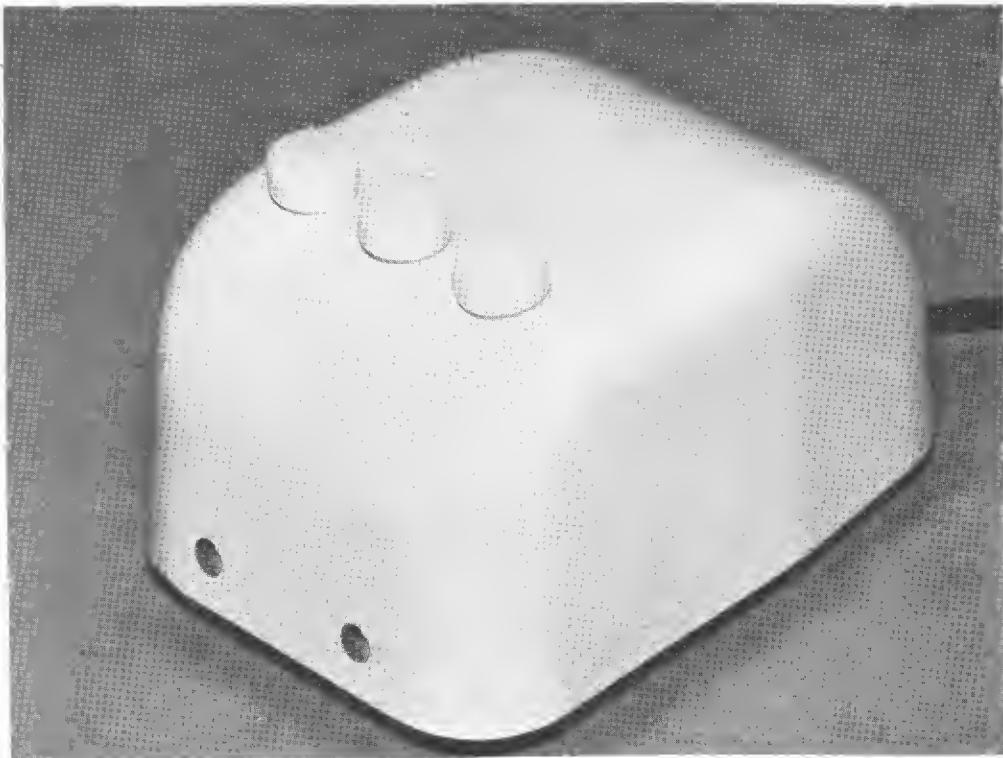


Figure 11. Mouse, Graphic Input Device.

The Terminate button causes the same action as the Set Point button except that a prescribed control character is sent in place of the FS character. Normally this character would be a terminate character to the system, such as LF.

If the Line button is pushed, the Vector character (RS) is sent, followed by four binary characters to represent the relative vector from the last beam position. The format for these binary characters is identical to the format for the Long Vector command which the ARDS controller output section interprets. An FS character ends this message also. Since the messages sent to the computer normally are also interpreted by the output section of ARDS, that line will plot on the scope and its end point becomes the last beam position for any new line.

3.1.1 The Mouse

The Mouse is a simple, two-dimensional controller for positioning the cursor on the screen. The Mouse rests on two wheels and a ball bearing support pin so that it can easily be rolled about on a flat surface. Moving the mouse around on the surface causes the cursor to follow in an identical manner.

When the mouse is moved across a table top or other flat surface, the turning of the wheels, which are mounted perpendicular to each other, resolves the motion into its x and y components. These x and y components are fed via the Mouse's cable as analog voltages into the Graphic Input Electronics where they are used to position the cursor on the screen. Three buttons are mounted on top of the Mouse which allow the user to transmit the cursor position or its vector value to the computer, as described in the previous section.

In order to permit the user to put the cursor position under the computers control, a Mouse Trap is provided. When the Mouse is in this disk-shaped tray, the cursor follows the x and y integrator voltages rather than the Mouse. A switch on the trap also allows the user to turn off the cursor entirely.

3.1.2 Joystick

The Joystick is an alternative graphic input positioning device. Like the Mouse, it provides analog voltages for x and y to control the cursor.

The same three push button controls for generating graphic input messages are provided on the Joystick housing. In addition the two switches for turning off the cursor, and selecting the signal source for the cursor, are mounted on this housing.

3.2 Multi-Symbol Sizes

This option permits the computer program to specify one of four values for the horizontal dimension of symbols and one of four values for the vertical dimension. Thus, 16 symbol formats are available. The sizes range in ratios of 1.0, 1.33, 1.67, and 2.0.

The symbol size is selected in the key character mode % (045 octal). The first argument character of this mode is interpreted as shown below:

b8	b7	b6	b5	b4	b3	b2	b1
P	1	Not Used		Y Size Select	X Size Select		

Size Selection	X		Y	
	b2	b1	b4	b3
1.0	0	0	0	0
1.33	0	1	0	1
1.67	1	0	1	0
2.0	1	1	1	1

Thus, to set symbol size and return to symbol mode the character string would be:

GS % X FS

where X is the argument character which specifies the symbol size selected.

All succeeding characters will plot at this size until a new size is selected or until ARDS Reset button is pushed.

Note that the LF is not varied by the symbol size control. Thus proper line spacing for sizes other than the smallest should be done by software using Set Points.

3.3 Right Margin Detect Option

This option causes the bell to be rung and a line-feed and carriage-return to be forced when the right margin is reached by a symbol command.

The right margin value can be set to be any position on the right side of the screen, but is normally taken to be on the right edge of the screen at the end of 80 symbols.

3.4 Multi-Scope Electronics Option

The Multi-Scope Electronics Option allows up to six display units to be driven from a single controller, each with its own picture. This is useful where a user wants to be able to view several different pictures at one time and erase and redraw them independently. It also has application in a multiple display system where there is no input, or where input multiplexing can be handled externally.

To control the selection of the scope to be written, the key character & with a single argument character is used. Each bit of this argument controls one display. If it is a one, that scope will be active for the subsequent output data. Thus, to select output to the third of six scopes, the computer would transmit the following character sequence:

GS & D FS.

The GS puts ARDS into graphic mode. & is the key character for multi-scope selection mode. D is the argument character. Its binary code is 000100. Thus it selects the third scope. FS returns ARDS to symbol mode.

3.5 High-Speed Option

When ARDS is directly connected to a computer rather than connected via a telephone line (and where the data rate for that connection is high), it is possible to operate ARDS at a significantly higher plotting rate. This is because at 1200 bits per second ARDS is normally waiting for data.

Symbols require between 1 and 2 milliseconds (depending on the particular character) to plot. This means ARDS can print between 500 and 1000 symbols per second if the data can be presented at that speed.

Similarly ARDS requires between 1 and 8 milliseconds to draw a vector, depending on the vector length. At 1200 bits per second, ARDS must wait 33.3 milliseconds to get the four data characters it needs to draw a long vector. If data is made available fast enough, plotting speed improvements of from 4 to 15 times can be obtained.

The High-Speed Option contains the necessary electronics to allow ARDS to operate at these higher speeds. This includes providing the signal, DEMAND, back to the computer whenever ARDS is ready to accept new output data. When the computer detects DEMAND, it sends out its next waiting character. The format of the data transmitted is not changed from the standard ARDS, but is sent at a 100,000 bits per second clock rate rather than 1200 bits per second. DEMAND goes off as soon as the start bit of the new character is received. When ARDS has taken action on that character, DEMAND is raised to get new data.

It should be noted that the clock speed of the input section of ARDS is unaffected by this High Speed Option. If it is more convenient for the computer interface to operate in and out at the same clock speed, the ARDS data transmit clock can be made 100,000 bits per second. This does not affect the user at all, since his typing speed is so slow in comparison.

3.6 Answerback Option

In environments where many scopes dial into a single computer, it is often advantageous for that computer to know which specific terminal is calling. The Answerback Option provides ARDS with a unique eight character identification. With this option, whenever the ASCII character ENQ (005 octal) is received, this eight character ID message is returned. The code for this message is specified by the customer.

Because of shared electronics, Answerback can only be provided on machines which have the Graphic Input Electronics Option.

3.7 Multiple Symbol Set Option

Some applications for displays call for frequent plotting of symbols which are not included in the standard ASCII set. ARDS symbol set can be expanded to 192 printing symbols by incorporation of the Multiple Symbol Set Option.

This electronics provides a larger Read Only Memory which defines the second set of 96 symbols. Limitations on what these symbols can be are imposed by the rules that they must be able to be defined in the standard 7 x 9 dot matrix used for the normal symbol set. Note that this matrix can be dropped two dot positions for symbols which go below the line.

The character codes available for the new 96 symbols are the same 96 used in ASCII for printing symbols. Essentially, the 192 printing symbols are divided into two sets of 96 each; a flip flop controls which set is active. This flip flop is set under program control by the codes Shift In (016 octal) and Shift Out (017 octal). Shift In selects the normal ASCII set. Shift Out selects the non-standard set. This action is entirely transparent to graphic commands. Control codes such as Form Feed, Carriage Return, Back Space, etc., are independent of the font.

When ARDS is first turned on, the state of the flip flop is indeterminate and either set is equally likely to be active. The user therefore must plan to select the desired set whenever ARDS is first turned on.

CHAPTER 4

ARDS OPERATING INSTRUCTIONS

4.0 Applying Power

When the power switch is turned on, lights on the scope ERASE button and either PROCEED or WAIT on the keyboard should light. ARDS will take approximately a minute to warm up to operating state. During this time the screen will come up fully written. Pushing the ERASE button on the scope will clear the screen. It is also recommended that the ARDS RESET and PARITY buttons be pushed at this time to ensure that the display is ready for activity. The keyboard may be inactive at this time depending on the status of the device ARDS is connected to.

4.1 Establish Communication

The next step depends upon the communication link used to the computer. If this is a direct connection or a private wire phone-line connection ARDS is ready to operate. Assuming power is provided to the communications link, ARDS should be in the PROCEED state and any typing will enter the computer.

If ARDS is connected via dialed up phone lines, the computer must be called to establish the line. When the link has been made, the computer may take the line and send out a message. When the user has the line, the PROCEED light will appear, indicating the line is free. At this time the keyboard is active.

4.2 General Operation

The keyboard acts as any teletypewriter keyboard. Typing a key causes a character to be sent to the computer. Unless specifically inhibited by receipt of the character DC2, data transmitted to the computer from the keyboard will be coupled back to the output section of ARDS causing it to print on the screen. This link between keyboard and printer is necessary in half-duplex operations.

In full-duplex operation, some systems make the link at the computer, so that all characters sent to it are echoed back to ARDS. In this case local echo should be suppressed. This can be accomplished by typing DC2 (Control and R simultaneously).

Although the keyboard contains only 58 keys, all 128 ASCII code combinations can be generated from it. The shift key allows shift between upper and lower case character, as identified on the key caps. The Control key permits the communication control and carriage control characters to be created. While this key is depressed, bit 7 and bit 6 are forced to zero. Thus any key struck while the Control key is held down will produce a Control code rather than its normal code.

The Erase key sends the Form Feed character to the computer and causes the beam to move to the upper left hand corner of the screen and erases the screen. The ERASE button on the scope erases the screen but does not effect the beam position nor signal the computer in any way.

If no activity takes place on the screen for a period of 1 to 2 minutes, the screen will automatically drop into Holding mode. In this mode, screen brightness is turned down to a bare minimum to maintain the image. The viewer will have difficulty seeing anything. Pushing the View button or writing anything on the scope will restore the picture to full brightness. The Holding mode is provided to extend the life of the direct view storage tube.

Mounted on the keyboard section of ARDS are four buttons and lights. The PROCEED/WAIT light is described in Section 1.3; it is an indicator of line control in a half-duplex operation.

The PARITY light comes on whenever a character is received with improper parity. This serves as an indicator that incorrect data has been received. This light is the response ARDS makes to incorrect parity. The bad character will be printed just as though no parity error occurred. The user may reset the PARITY light by pushing the lighted button.

The RESET button is provided to return ARDS to a known stable state. It is particularly valuable when the machine is first turned on, since the state of the machine is not guaranteed when power is first applied. Pushing RESET, forces ARDS to symbol mode, enables the output section to receive data from the computer, and resets the integrators to center screen.

The BREAK button is described in Sections 1.3, 2.1, and 2.2. It is provided for systems that respond to the BREAK interrupt. BREAK is especially useful in a half-duplex operation.

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